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Variability and automaticity in highly practiced cello performance

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Performance cues are the landmarks of a piece of music that a performer attends to during performance. While most aspects of a performance become automatic with practice, performance cues provide the musician with a means of conscious control of otherwise automatic motor sequences. Experienced performers strategically select the performance cues that they need to attend to during performance in order to achieve the musical and technical effects that they want. Previous evidence for this claim has come from practice and recall. This study examined effects of performance cues on live and practice performances. We recorded the practice and public performances of an experienced cellist learning the *Prelude* from J.S. Bach's *Suite No. 6* for solo cello over a two-year period. We measured bar-to-bar fluctuations in sound-level and tempo for 8 practice, 7 live, and 12 "lab" performances, the latter played with exaggerated, normal, or minimal expression. Expressive and interpretive performance cues were consistently associated with slower tempi and lower sound-levels. These effects were larger in exaggerated than in minimally expressive lab performances, and there were similar differences between the live performances. The effects suggest performance cues provide a way of controlling highly practiced performance.

Keywords: performance; expression; interpretation; memory; practice

Performance cues are the landmarks of a piece of music that a performer attends to during performance (Chaffin *et al.* 2002, Chaffin and Logan 2006). While most aspects of a performance become automatic with practice, performance cues provide the musician with a means of conscious control of otherwise automatic motor sequences. Experienced performers strategically

select the cues that they need to attend to during performance in order to achieve the musical and technical effects that they want. Previous support for this claim has been indirect, based primarily on evidence from practice and free recall of the score. This study examined effects of performance cues on live and practice performances.

An experienced cellist learned the *Prelude* from J.S. Bach's *Suite No. 6* for solo cello. We recorded all practice and public performances for two years and examined them to see whether we could identify musical gestures corresponding to interpretive and expressive performance cues reported by the cellist.

METHOD

Participant

Tânia Lisboa was trained in classical cello and piano in Brazil, England, and France, and performs regularly as a cello soloist.

Materials

The *Prelude* from J.S. Bach's *Suite No. 6* for solo cello explores both the mellow quality and virtuoso aspects of the instrument.

We examined public performances (n=7), polished practice performances starting the day before the first public performance (n=8), and 12 "lab" performances done at the time of the later live performances. In the lab performances, the cellist performed for small audiences with exaggerated (n=2), normal (n=6), or minimal expression (n=4).

Procedure

The cellist video-recorded her practice and public performances from the first time she sat down with the *Prelude* until the eighth public performance 92 weeks later. The total time spent in practice was approximately 34 hours.

The cellist reported all the decisions she made about technique, interpretation, and performance by marking them on copies of the score. Of concern here are her reports of performance cues for musical structure, expression, interpretation, intonation, and three types of cues for basic technique: cues for right hand (bowing and changing strings) and left hand (fingering and hand position).

We measured half-bar to half-bar fluctuations in sound-level and tempo for the 27 performances. Factor analysis grouped similar performances together. Regression analyses identified fluctuations in tempo and sound-

level that were related to performance cues. Analyses of variance compared these effects across performances.

RESULTS

Factor analysis identified two factors for both tempo and sound-level. One factor was interpreted as reflecting expressivity; the heaviest loadings were for extra-expressive lab performances and lowest loadings were for non-expressive lab performances. The second factor was interpreted as reflecting the tension felt by the cellist about the performance; the highest loadings were for the first two non-expressive lab performances, which the cellist found very difficult, and the lowest loadings were for practice performances, in which the cellist would have been more relaxed. Consistent with these interpretations, Figure 1 shows that decreases in tempo were more closely aligned with expressive performance cues for factor 1 (expressive performances) than for factor 2 (tense/non-expressive) performances.

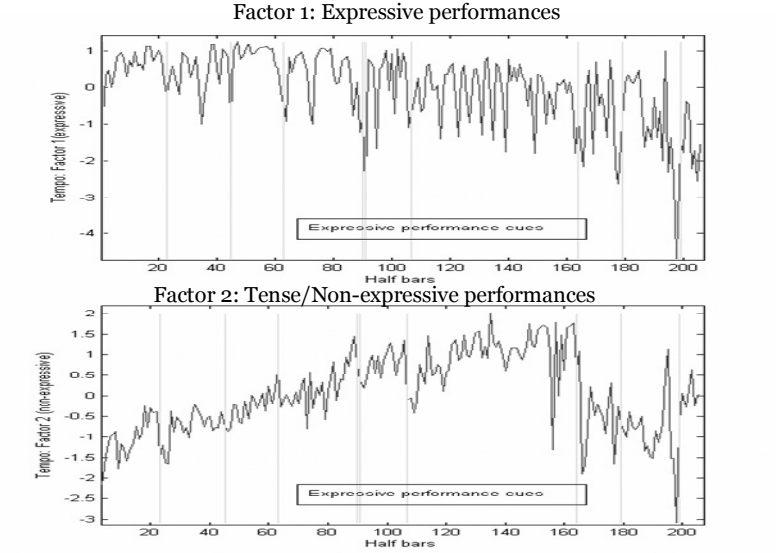

Figure 1. Factor scores representing tempo (per half-bar) for expressive (Factor 1, top panel) and tense/non-expressive (Factor 2, bottom panel) performances. Vertical lines showing the location of expressive performance cues correspond with tempo minima more closely for factor 1 than for factor 2.

Table 1. Regression coefficients for effects on *tempo* of predictors representing performance cues and other musical properties, and *F* values for differences between factors in the size of the effects.

	Factor 1 (expressive)	*Factor 2 (tense)*	*Differences (F)*
Performance cues			
Expressive intensity	-0.19**	-0.16*	0.04
Expressive perf. cue	-0.39***	0.07	21.53***
" " " : serial position from	-0.18**	0.60***	52.74***
Interpretive perf. cue	-0.25***	-0.00	5.77**
" " " : bar before	-0.06***	-0.01	0.35
" " " : serial position from	-0.28***	0.43***	42.39***
Intonation perf. cue	-0.16	-0.17	0.00
" " " : serial position from	0.37***	-0.02	4.80*
Bowing perf. cue	-0.13	-0.04	0.64
Other musical properties			
Phrasing	-0.23*	-0.02	1.36
" ": serial position from	-0.11	-0.20*	0.26
Phrase repeated (switch)	0.11*	0.05	0.43
R^2	0.56***	0.58***	

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Regression analyses showed that expressive performance cues were consistently associated with slower tempi (Table 1) and lower sound-levels (Table 2). The effect for tempo was larger for expressive (factor 1) than for tense performances (factor 2), and this difference was statistically reliable.

The effects show that the correspondences between expressive performance cues and tempo that are apparent in Figure 1 (top panel) were significant. Similar comparisons (not presented here) between the different types of lab performance showed similar differences. These effects support the interpretation of factor 1 as representing expressive performances and factor 2 as representing tense (less expressive) performances.

There were additional reliable differences between the two types of performance (see Tables 1 and 2, column 4). For tempo, the differences were confined to performance cues (Table 1). For sound-level most of the differences were for other musical properties. Performance cues were responsible for *some, but not all,* of the reliable differences between the performances.

Table 2. Regression coefficients for effects on *sound-level* of predictors representing performance cues and other musical properties, and *F* values for differences between factors in the size of the effects.

	Factor 1 (expressive)	*Factor 2 (tense)*	*Differences (F)*
Performance cues			
Expressive intensity	0.21**	0.02	2.83~
Express. cue: serial pos. from	0.19**	-0.13~	10.02**
Inter. cue: serial pos. from	0.01	-0.17*	3.34~
Fingering/hand pos. perf. cue	-0.18*	-0.03	1.72
Other musical properties			
Dynamic level (e.g. *p*, *f*)	0.41***	-0.12	27.72***
Dynamic change (e.g. *cresc.*)	0.19**	0.05	2.48
Phrasing	-0.02	-0.36**	4.13*
Phrasing: 2nd ½-bar in phrase	0.12	-0.16~	5.03*
Phrasing: serial position	0.10	-0.42***	10.05**
Switch: bar before	0.16**	-0.02	4.33*
Technical difficulty rating	-0.02	0.39***	7.49**
R^2	0.47***	0.42***	

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

DISCUSSION

Performance cues were systematically related to fluctuations in tempo and sound-level, complementing similar findings by Chaffin *et al.* (2007). The earlier results appeared, however, to reflect the performer's desire to avoid wrong notes, whereas the present effects appear to be due to musical interpretation. The results support the suggestion that musicians use performance cues to achieve their interpretive and expressive goals in performance.

The effects of performance cues differed across performances. The differences support the claim that performance cues provided the musician with control of the automatic motor sequences involved in performance. In the lab performances, the effects on tempo of expressive and interpretive cues were consistent with the cellist's goals of playing with exaggerated, normal, or minimal expression. Decreases in tempo at these cues were bigger in extra-expressive performances and smaller in non-expressive performances. Similar differences between the two factors suggest that similar variation in musical intention were present in other performances and, thus, that spontaneous differences between performances were attributable to perform-

ance cues. The differences between the two factors suggest that performance cues provided the musician with control of the automatic motor sequences required for performance.

For tempo, all the statistically reliable differences between performances were attributable to performance cues. There were no reliable differences due to other musical properties. For sound-level, in contrast, most differences between performances involved other musical properties. These results show that some reliable differences between performances are due to performance cues, while others are due to musical properties that are not encoded in memory by performance cues. Performance cues are responsible for *some, but not all,* differences between repeated performances of the same piece.

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